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Roberto Roson and Martina Sartori

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IEFE - The Center for Research on Energy and Environmental Economics and Policy at Bocconi University
via Guglielmo Röntgen, 1 - 20136 Milano
tel. 02.5836.3820 - fax 02.5836.3890
www.iefe.unibocconi.it – iefe@unibocconi.it

A Decomposition and Comparison Analysis of International Water Footprint Time Series

Roberto Roson*
Cà Foscari University, Venice and IEFE, Bocconi University, Milan

Martina Sartori
University of Trento and IEFE, Bocconi University, Milan

ABSTRACT

This paper deals with the construction, decomposition and comparison of water footprint time series in 40 countries and one aggregate macro-region, in the period 1995-2009. The analysis of the different "footpaths" allows us to investigate on the possible causes behind the time evolution of water footprints in the various countries.
We notice that the physical and economic impact of economic growth on water resources has been significantly lower than what it could have been, for several reasons. First, both production and consumption patterns are shifting away from water intensive goods. Second, a large part of consumed water is actually not blue water, susceptible of alternative uses. Finally, we do not find strong evidence of gains in the economic productivity of water (dollars per water unit) in many countries, but we do find evidence of indirect efficiency gains, related to the composition of factors in the production processes.

JEL Codes: O13, O57, Q25, Q56.

KEYWORDS: Water, Water Footprint, Structural Decomposition, Cross Country Comparison, World Input-Output Database.

1. Introduction

The water footprint, and related concepts like the ecological footprint (Costanza, 2000), or the carbon footprint (Weber and Matthews, 2008) are aimed at gauging the impact of economic activities on natural resources. As such, the water footprint is an intrinsically static notion, since it measures the amount of water usage in a specific time period. However, a series of water footprints could be computed for a number of consecutive periods, and it would be interesting to assess how the "footpath" evolves, and why.

The construction of a water footpath is made difficult by demanding data requirements. To the best of our knowledge, only Cazcarro, Duarte and Sánchez-Chóliz (2013) have estimated and analysed a water footprint time series (for Spain), whereas Wiedmann et al. (2010) undertook a similar investigation for carbon footprint in the U.K.. These are single country studies and comparative analyses of different footpaths among different countries have not been realized as yet.

This paper is precisely about the construction, decomposition and comparison of water footprint time series in 40 countries and one aggregate macro-region, in the period 1995-2009. The estimation of water footpaths is made possible by the availability of time series for multi-regional input-output

* Corresponding Author. Dipartimento di Economia, Cannaregio 873, I-30121, Venezia, Italy. E-mail: roson@unive.it .

tables, realized by the World Input-Output Database (WIOD) project (Dietzenbacher et al., 2013).

The next section illustrates how water footprints have been estimated and how the inter-annual variations have been decomposed. We compute production and consumption footprints, that is those related to production activities (using water resources in the country where production is carried out) and to consumption levels (requiring water from different regions through imported commodities). In both cases, we break down the changes as variations in (1) the aggregate activity level (total gross production, total consumption), (2) the industrial composition, (3) the water efficiency or productivity. Furthermore, we separately compute production footpaths for blue, green and grey water. For consumption footpaths, we separate footprints for intermediate and final consumption.[1]

The analysis and comparison of the different footpaths, which is presented in the third section of this paper, allows us to speculate about the causes behind the time evolution of water footprints in the various countries. This analysis provides some general insights, which are useful for a better understanding of how the pressure on water resources may change in the future.

A concluding section summarizes and lays out some final comments.

2. Methodology and Data

The WIOD project provides complete multi-regional input-output tables for the years 1995-2009,[2] including all 27 countries in the European Union, 17 other countries and one remaining "Rest of the World" aggregate region. Each annual table gives information about production levels (in US dollars) for 35 industries in every region, as well as intermediate industrial consumption (for all industries), public and private consumption, investments and inventory changes. All consumption items are expressed as vectors, in which both the industrial and the regional origins of trade flows are specified.

The input-output tables, which are estimated on the basis of official national accounts (Dietzenbacher et al., 2013), are accompanied by "satellite environmental accounts", expressed in physical units of measure (Genty, Arto and Neuwahl, 2012). The variables covered are: use of energy; emission of main greenhouse gases; emission of other main air pollutants; use of mineral and fossil resources; land and water use. For water, estimates are obtained through elaboration from original data by Mekonnen and Hoekstra (2010a-b, 2011a-b) and separately consider blue, green and grey water.

The high sectoral disaggregation of WIOD data is essential to compute water footprints. This is because all footprints are scalar numbers (f), obtainable through multiplication of a row vector $\boldsymbol{w}$ of water coefficients (water usage per unit) by a column vector $\boldsymbol{a}$ of economic activity levels:

$$f = \boldsymbol{w}' \cdot \boldsymbol{a} \quad (1)$$

In our setting, $\boldsymbol{w}$ includes ratios of water industrial consumption over output value (1000 cubic meters per dollar). When estimating production footprints, in a given year and country, the $\boldsymbol{w}$ vector includes 35 elements (one for each industry), and the $\boldsymbol{a}$ vector corresponds to the vector of industrial output.[3] In the case of consumption footprint, the $\boldsymbol{w}$ vector includes 35x41 elements (industry by country), and the

1 We disregard water footprints stemming from investment demand, as this is highly volatile and often negative, due to changes in inventories.

2 More recent years are available, but unfortunately they lack data for environmental variables.

3 To get the water footprint for production, it would be simpler to just sum up the industrial water usage, directly from WIOD data. The formulation above, however, is more general, and applicable to consumption footprints and decomposition analysis.

$\boldsymbol{a}$ vector is the sum over all 35+5 consumption vectors.[4]

The same formula is applicable for the computation of components of total water footprints. For example, to get the blue water footprint, it is sufficient to consider only blue water in the vector $\boldsymbol{w}$. Analogously, to get the footprint due to final consumption, only the latter component of demand should be inserted into the vector $\boldsymbol{a}$.

The change of a water footprint from one year t to the following year $t+1$ can be traced back to variations in the elements of vectors $\boldsymbol{w}$ and $\boldsymbol{a}$. We can further split the variations in the $\boldsymbol{a}$ vector by proportionally scaling up all elements in $\boldsymbol{a}$ by a factor g, such that:

$$\sum_{i=1}^{35} g\, a_t^i = \sum_{i=1}^{35} a_{t+1}^i \qquad (2)$$

This allows us to decompose the variation in the footprint indicator in three steps:

$$f_{t+1} - f_t = (\boldsymbol{w_t}' \cdot \boldsymbol{a_t})(g-1) + \boldsymbol{w_t}' \cdot (\boldsymbol{a_{t+1}} - g\,\boldsymbol{a_t}) + (\boldsymbol{w}'_{t+1} - \boldsymbol{w_t}') \cdot \boldsymbol{a_{t+1}} \qquad (3)$$

The first step, corresponding to the first element of the sum in the right hand side of (3) is readily interpreted as the change in water footprint induced by the change in aggregate activity (total production or consumption levels). The second step can be interpreted as the contribution due to variations in the structure of the $\boldsymbol{a}$ vector (production or consumption patterns). Finally, the last element refers to variations in the elements of the $\boldsymbol{w}$ vector, expressing the coefficients of water productivity.

In this work, we estimated water footprints for production and consumption for 41 regions and 15 years, from 1995 to 2009. In all series, we consider the percentage variation[5] of the water footprint from the previous year, and we decompose this change in the three elements of activity level, activity pattern, and water efficiency. We also produce production footprint time series for blue, green and grey water, as well as separate footprints for intermediate and final consumption. The results are presented and discussed in the following.

3. Results

Series of stacked graphs, displaying “footpaths” for individual countries are displayed in the Appendix. Here we present and comment some general findings.

Table 1 reports some summary statistics about the water footprint time series for production. Average annual growth rates are displayed in the second column. We can see that most countries exhibit positive, but not very large increments, whereas some other countries reduce their footprint. The largest increases, above 3% of average annual growth rate, are found in Brazil, China, Spain, Estonia, Indonesia, Lithuania and Latvia. These are all countries which have experienced sustained growth in the period 1995-2009 and an expansion of production in agricultural sectors. Bulgaria, Cyprus, Greece, Italy, Japan, Malta, Portugal, Romania and Slovakia have diminished their production footprint in the

4 This because, in all countries, there are 35 industries generating demand for intermediate inputs (whose production may require water), plus one household sector, one private no-profit organizations sector, one public sector, investments in physical capital formation, changes in inventory stocks. Notice that intermediate inputs consumption is included. Because of this, contrary to Antonelli, Roson and Sartori (2012) and Cazcarro, Duarte and Sánchez-Chóliz (2013), we do not need to take into account the Leontief inverse matrix when computing the consumption water footprint.

5 More precisely, the difference in logarithms.

same period.

We decompose the average variation in three stages, according to equation (3). The third column (Var. levels1) displays the average growth rate attributable to the aggregate increase in production levels. As expected, all rates are positive, with the exception of Japan, which has been affected by a prolonged recession. Generally speaking, we think that figures in this column are somewhat too high and possibly inconsistent with macroeconomic data. Furthermore, the associated time series display high volatility.

As an alternative measure of the component due to changes in aggregate activity level, we recompute the average annual variation, using real GDP growth rates (World Bank, 2014) instead of the *g* factor as defined in equation (2). Results, which are more homogeneous and with lower figures, are shown in the fourth column (Var. levels2). The two values could be interpreted as lower and upper bounds for our estimates of the aggregate level component.

The next column (Var. Struct.) gives the variation of footprint induced by changes in the pattern of industrial production. Interestingly, all rates (with minor exceptions in Austria, Brazil and Indonesia) are negative and often quite significantly so. This means that the productive structure in most economies has shifted away from water intensive industries, most notably agriculture. Furthermore, the correlation coefficient between average changes in levels and average changes in patterns is found to be -0.55, suggesting that high-growth countries are also countries in which the share of agriculture shrinks at a faster pace, possibly because of the production expansion in manufacturing and services.

The last two columns display the remaining component attributable to water efficiency. Here we have two values, corresponding to the two values of the changes in levels. A negative number should be interpreted as an improvement in water efficiency, that is in the value of production per unit of water. We can see that improvements in water productivity are typically found only when high growth rates in aggregate production levels are assumed, whereas this result no more holds true, in general, with more prudential growth rates.

Perhaps one may be surprised, and suspicious, about the finding that water productivity may have worsen in many countries, since improvements in cultivation and irrigation techniques should have improved efficiency. This reasoning is not readily applicable at the aggregate level, though, because we are not considering here production factors different from water and the output is measured in monetary terms. For instance, higher water usage could partly compensate lower productivity of other inputs, including non-market factors associated with climatic conditions.

Table 2 provides results for a similar kind of exercise, this time applied to the series of consumption water footprints. The country profile of average annual growth rates (second column) is quite similar to the one computed for production footprints. Significant divergences can be found in small, open economies like Belgium (3.53% for consumption vs. 0.58% for production), whereas differences are slight in large, relatively closed economies, like the United States (1.26% vs. 1.28%).

Even in this case we supply two different estimates for the average change due to variations in aggregate consumption levels. Figures in the fourth column (Var. levels2) are the same as in Table 1, because we have applied the same GDP growth rates for consumption as well.[6]

6 The reason why we have used the same rates for both production and consumption is the following one. Estimates of gross production levels are not generally available for all years. However, changes in gross production are approximately the same as changes in net production (or GDP) if the share of intermediate inputs in total production costs and the industrial structure do not change significantly. Analogously, estimates of aggregate consumption (including intermediate inputs) are not available, but GDP growth rates give a reasonable approximation if the share of consumption in national income does not vary much (from one year to the next).

Table 1 – Production WFs (yearly av. changes) - decomposition

Country	WF av. var.	Var. levels1	Var. levels2	Var. struct.	Var. eff.1	Var. eff.2
Australia	0.88%	6.87%	3.55%	-3.28%	-2.71%	0.61%
Austria	0.48%	4.26%	2.08%	0.91%	-4.70%	-2.52%
Belgium	0.58%	3.87%	1.86%	-3.26%	-0.03%	1.98%
Bulgaria	-0.19%	9.42%	3.07%	-6.69%	-2.93%	3.43%
Brazil	3.16%	5.54%	2.79%	0.62%	-3.00%	-0.25%
Canada	1.32%	6.05%	2.57%	-2.38%	-2.35%	1.12%
China	3.39%	14.87%	10.01%	-4.40%	-7.08%	-2.22%
Cyprus	-4.24%	7.16%	3.32%	-5.21%	-6.19%	-2.36%
Czech Rep.	0.91%	8.89%	2.94%	-5.30%	-2.69%	3.26%
Germany	1.18%	2.29%	1.09%	-1.29%	0.18%	1.38%
Denmark	0.86%	4.36%	1.36%	-3.95%	0.45%	3.44%
Spain	3.71%	6.71%	2.96%	-4.20%	1.20%	4.95%
Estonia	3.95%	10.74%	4.93%	-5.58%	-1.22%	4.60%
Finland	0.75%	4.80%	2.77%	-2.29%	-1.76%	0.27%
France	0.99%	3.91%	1.65%	-2.59%	-0.33%	1.92%
Great Britain	0.10%	4.60%	2.41%	-4.52%	0.03%	2.22%
Greece	-1.05%	5.93%	3.08%	-5.62%	-1.36%	1.48%
Hungary	0.74%	7.59%	2.41%	-5.01%	-1.84%	3.34%
Indonesia	3.49%	6.04%	3.65%	0.23%	-2.78%	-0.39%
India	1.51%	9.07%	6.83%	-3.07%	-4.49%	-2.25%
Ireland	0.30%	9.11%	5.56%	-11.45%	2.64%	6.19%
Italy	-0.30%	4.62%	0.84%	-2.25%	-2.67%	1.11%
Japan	-0.99%	-0.36%	0.54%	-0.48%	-0.15%	-1.05%
Korea	0.53%	4.52%	4.62%	-4.19%	0.20%	0.10%
Lithuania	4.45%	11.35%	4.81%	-6.64%	-0.26%	6.28%
Luxembourg	1.14%	9.30%	3.85%	-7.41%	-0.76%	4.70%
Latvia	4.26%	12.31%	4.96%	-5.14%	-2.91%	4.45%
Mexico	0.59%	6.88%	2.76%	-1.72%	-4.57%	-0.45%
Malta	-2.16%	6.10%	2.70%	-1.34%	-6.92%	-3.52%
Netherlands	0.01%	4.71%	2.31%	-2.86%	-1.84%	0.56%
Poland	0.87%	8.46%	4.46%	-5.33%	-2.27%	1.73%
Portugal	-1.37%	5.06%	1.88%	-2.80%	-3.63%	-0.45%
Romania	-0.52%	9.77%	2.81%	-4.95%	-5.34%	1.62%
Russia	2.15%	9.10%	3.84%	-3.71%	-3.25%	2.02%
Slovakia	-0.07%	10.43%	4.38%	-3.67%	-6.84%	-0.79%
Slovenia	1.17%	6.20%	3.43%	-2.63%	-2.41%	0.36%
Sweden	0.06%	3.53%	2.36%	-0.55%	-2.92%	-1.75%
Turkey	0.93%	7.64%	3.68%	-1.92%	-4.79%	-0.84%
Taiwan	1.58%	2.39%	3.91%	-3.78%	2.98%	1.46%
United States	1.28%	4.36%	2.55%	-1.67%	-1.41%	0.39%
Rest of World	2.63%	6.88%	3.29%	-0.82%	-3.43%	0.16%

Table 2 – Consumption WFs (yearly av. changes) - decomposition

Country	WF av. var.	Var. levels1	Var. levels2	Var. struct.	Var. eff.1	Var. eff.2
Australia	1.91%	7.37%	3.55%	-2.75%	-2.72%	1.11%
Austria	0.70%	5.50%	2.08%	-0.73%	-4.06%	-0.64%
Belgium	3.53%	6.13%	1.86%	-0.26%	-2.34%	1.93%
Bulgaria	-1.53%	12.86%	3.07%	-11.57%	-2.82%	6.98%
Brazil	2.62%	6.65%	2.79%	-1.01%	-3.03%	0.84%
Canada	1.01%	7.75%	2.57%	-4.31%	-2.43%	2.75%
China	3.86%	13.80%	10.01%	-3.03%	-6.91%	-3.12%
Cyprus	-0.74%	9.77%	3.32%	-5.96%	-4.55%	1.90%
Czech Rep.	0.89%	12.27%	2.94%	-8.63%	-2.75%	6.58%
Germany	0.85%	4.04%	1.09%	-1.91%	-1.28%	1.68%
Denmark	-0.48%	6.95%	1.36%	-6.90%	-0.53%	5.05%
Spain	2.63%	8.56%	2.96%	-6.04%	0.11%	5.71%
Estonia	4.20%	14.48%	4.93%	-8.77%	-1.51%	8.04%
Finland	0.90%	8.44%	2.77%	-5.33%	-2.21%	3.46%
France	0.65%	5.42%	1.65%	-3.93%	-0.83%	2.93%
Great Britain	0.47%	7.78%	2.41%	-6.00%	-1.31%	4.05%
Greece	-0.33%	7.73%	3.08%	-6.37%	-1.68%	2.96%
Hungary	-0.11%	11.26%	2.41%	-9.50%	-1.87%	6.98%
Indonesia	3.51%	4.70%	3.65%	1.67%	-2.87%	-1.81%
India	1.54%	8.80%	6.83%	-2.77%	-4.49%	-2.52%
Ireland	1.21%	12.46%	5.56%	-12.12%	0.88%	7.77%
Italy	-0.34%	7.12%	0.84%	-4.72%	-2.74%	3.55%
Japan	-2.06%	1.10%	0.54%	-1.59%	-1.57%	-1.01%
Korea	0.03%	7.11%	4.62%	-5.06%	-2.01%	0.47%
Lithuania	3.41%	15.82%	4.81%	-11.90%	-0.51%	10.50%
Luxembourg	-1.88%	11.63%	3.85%	-10.88%	-2.64%	5.14%
Latvia	4.45%	16.18%	4.96%	-8.78%	-2.94%	8.28%
Mexico	1.25%	10.41%	2.76%	-4.85%	-4.31%	3.35%
Malta	-0.05%	10.47%	2.70%	-7.35%	-3.17%	4.59%
Netherlands	2.61%	6.39%	2.31%	-1.37%	-2.40%	1.68%
Poland	0.75%	12.59%	4.46%	-9.39%	-2.45%	5.68%
Portugal	-1.19%	7.08%	1.88%	-5.11%	-3.16%	2.04%
Romania	-0.34%	13.61%	2.81%	-8.72%	-5.24%	5.57%
Russia	2.81%	12.24%	3.84%	-6.17%	-3.26%	5.14%
Slovakia	0.16%	12.77%	4.38%	-6.47%	-6.13%	2.26%
Slovenia	0.60%	8.72%	3.43%	-5.64%	-2.48%	2.80%
Sweden	-0.17%	6.65%	2.36%	-3.78%	-3.04%	1.24%
Turkey	1.74%	10.43%	3.68%	-3.92%	-4.77%	1.98%
Taiwan	0.58%	4.28%	3.91%	-5.05%	1.35%	1.72%
United States	1.26%	5.78%	2.55%	-2.88%	-1.64%	1.59%
Rest of World	2.63%	7.05%	3.29%	-0.95%	-3.47%	0.29%

Variations in the water footprint induced by changes in the pattern of consumption are generally negative and wide. Furthermore, the correlation between level and pattern changes is larger (-0.75). This high correlation is consistent with an established fact: food consumption (accountable for most of the footprint) is known to have an income elasticity lower than one. In other words, food consumption increases less than proportionally with respect to income.

In Table 3, we compare the average growth rate of the production water footprints, with the corresponding averages computed by separately considering blue, green and grey water.

The term blue water refers to water stored in lakes, rivers, reservoirs, ponds and aquifers. Green water indicates the return flow of water, embedded into the soil moisture, to the atmosphere as evapotranspiration. Green water can only play a role as a productive factor in agriculture. Grey water refer to low-quality, not potable water normally recycled and used for irrigation purposes. The distinction between the three types of water is relevant in economic terms, because only blue water is susceptible of alternative uses and, as such, has an economic value.

An interesting aspect emerging from Table 3 is that average growth rates for blue water footprints are lower than aggregate averages in 63% of the countries, and are actually negative in some cases. For example Cyprus, a water stressed country, has achieved a -5.84% annual reduction in blue water consumed for productive purposes. Whenever blue water growth turns out to be lower than the aggregate water growth, we can say that the economic impact of the water footprint in a country is lower than the physical impact.

This finding is confirmed by the figures indicating the growth rates for grey water footprints. Here we have that average rates for grey water are higher than aggregate rates in 78% of the countries. Especially remarkable results have been obtained in the Baltic countries, China and Taiwan.

Summary statistics for water footprints, separately computed for final consumption (by households, no-profit organizations and government) and intermediate consumption (by domestic firms) are shown in Table 4.

Perhaps the most interesting fact emerging from the figures is that intermediate water consumption is growing less than final water consumption in most countries (71%), and again it displays negative variations in some cases. This phenomenon, which was also noticed in Spain by Cazcarro, Duarte and Sánchez-Chóliz (2013), can be interpreted as an indirect efficiency gain: you are saving water not because you use less water in the production process, but because you use less factors (e.g., agricultural goods), whose production requires water. This effect is particularly strong in Belgium, Great Britain, Greece, Lithuania and Slovakia.

Table 3 – Production WFs (yearly av. changes) – water types

Country	WF av. var.	WF a.v. blue	WF a.v. green	WF a.v. grey
Australia	0.88%	-1.06%	1.13%	1.35%
Austria	0.48%	0.60%	0.23%	0.71%
Belgium	0.58%	0.18%	0.24%	1.06%
Bulgaria	-0.19%	0.94%	-0.26%	-0.25%
Brazil	3.16%	2.94%	3.21%	2.88%
Canada	1.32%	0.61%	1.54%	2.49%
China	3.39%	4.14%	1.96%	5.81%
Cyprus	-4.24%	-5.84%	-3.38%	-5.62%
Czech Rep.	0.91%	0.77%	0.74%	1.59%
Germany	1.18%	-0.66%	1.43%	1.50%
Denmark	0.86%	0.48%	0.87%	0.90%
Spain	3.71%	2.94%	4.21%	2.34%
Estonia	3.95%	1.07%	3.73%	6.36%
Finland	0.75%	-0.11%	1.21%	1.11%
France	0.99%	-1.03%	1.33%	2.41%
Great Britain	0.10%	-0.35%	0.10%	0.31%
Greece	-1.05%	-0.73%	-1.19%	-0.95%
Hungary	0.74%	0.24%	0.94%	-0.05%
Indonesia	3.49%	1.74%	3.57%	3.49%
India	1.51%	1.65%	1.25%	2.62%
Ireland	0.30%	1.81%	-0.10%	2.22%
Italy	-0.30%	1.17%	-0.75%	-0.59%
Japan	-0.99%	-0.75%	-1.09%	-1.44%
Korea	0.53%	0.95%	0.34%	1.43%
Lithuania	4.45%	-0.04%	4.48%	6.10%
Luxembourg	1.14%	1.03%	1.27%	0.60%
Latvia	4.26%	1.09%	4.78%	5.37%
Mexico	0.59%	0.67%	0.52%	1.02%
Malta	-2.16%	-4.55%	-1.42%	-1.74%
Netherlands	0.01%	0.03%	-0.09%	0.56%
Poland	0.87%	2.96%	0.24%	2.83%
Portugal	-1.37%	-1.02%	-1.50%	-1.55%
Romania	-0.52%	-0.33%	-1.08%	2.70%
Russia	2.15%	0.63%	2.33%	2.59%
Slovakia	-0.07%	-0.71%	-0.10%	1.02%
Slovenia	1.17%	2.55%	-0.33%	1.24%
Sweden	0.06%	-0.24%	0.58%	0.88%
Turkey	0.93%	0.56%	0.81%	2.50%
Taiwan	1.58%	0.54%	1.12%	4.19%
United States	1.28%	0.28%	1.51%	1.35%
Rest of World	2.63%	2.00%	2.74%	2.95%

Table 4 – Consumption WFs (yearly av. changes) – categories

Country	WF av. var.	WF a.v. final	WF a.v. inter.
Australia	1.91%	3.13%	1.02%
Austria	0.70%	-0.83%	1.48%
Belgium	3.53%	6.64%	1.91%
Bulgaria	-1.53%	-5.34%	-0.17%
Brazil	2.62%	2.50%	2.86%
Canada	1.01%	1.78%	0.71%
China	3.86%	-1.10%	5.95%
Cyprus	-0.74%	0.06%	-1.04%
Czech Rep.	0.89%	3.11%	0.23%
Germany	0.85%	1.50%	0.32%
Denmark	-0.48%	2.27%	-1.14%
Spain	2.63%	3.16%	2.31%
Estonia	4.20%	5.66%	3.59%
Finland	0.90%	2.13%	0.74%
France	0.65%	1.17%	0.73%
Great Britain	0.47%	3.22%	-1.98%
Greece	-0.33%	3.46%	-3.32%
Hungary	-0.11%	0.47%	-0.22%
Indonesia	3.51%	4.45%	3.71%
India	1.54%	1.95%	1.45%
Ireland	1.21%	4.09%	0.69%
Italy	-0.34%	0.77%	-0.92%
Japan	-2.06%	-1.23%	-2.16%
Korea	0.03%	0.65%	0.22%
Lithuania	3.41%	7.56%	1.06%
Luxembourg	-1.88%	-0.84%	-2.55%
Latvia	4.45%	4.76%	4.56%
Mexico	1.25%	2.24%	1.15%
Malta	-0.05%	0.34%	-0.48%
Netherlands	2.61%	0.37%	3.44%
Poland	0.75%	1.57%	0.40%
Portugal	-1.19%	-0.20%	-1.52%
Romania	-0.34%	0.60%	-0.51%
Russia	2.81%	4.56%	1.91%
Slovakia	0.16%	4.25%	-1.50%
Slovenia	0.60%	2.86%	-0.36%
Sweden	-0.17%	0.26%	-0.15%
Turkey	1.74%	-0.07%	4.09%
Taiwan	0.58%	1.93%	-0.50%
United States	1.26%	3.24%	0.72%
Rest of World	2.63%	2.18%	3.13%

4. Conclusion

Our analysis of the international water footprint time series has revealed a number of notable facets of the interaction between economic development and water resources exploitation. In particular, we noticed that the physical and economic impact of economic growth on water resources has been significantly lower than what it could have been.

This is due to several reasons. First, both production and consumption patterns are shifting away from water intensive goods. The productive structure in many countries is changing, with a lower share of agriculture and higher shares for manufacturing and services. Also, food consumption grows at a lower rate than available income, thereby reducing (in relative terms) the water footprint of consumption.

Second, even when more water is used, a large part of it is actually not blue water, that is the type of water we have in mind when talking about water resources. The increase in the use of grey, recycled water has been especially remarkable in some regions.

Finally, we have not found strong evidence of gains in the economic productivity of water (dollars per water unit) in many countries. However, we did find evidence of indirect efficiency gains, due to a decreased demand for productive factors, requiring water in their own production processes.

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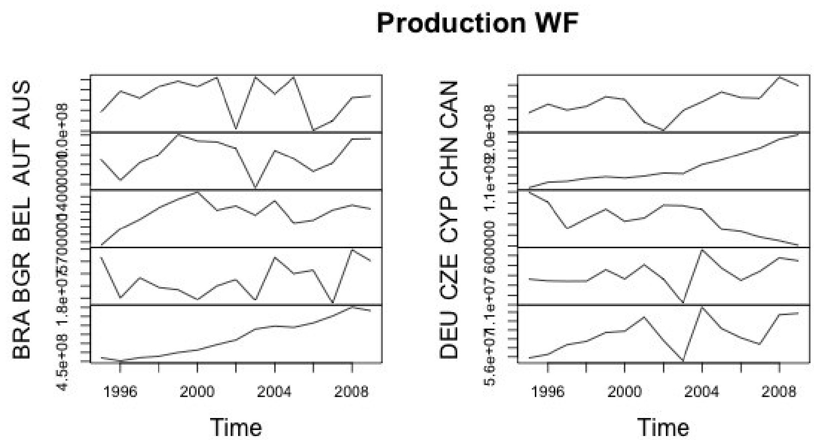
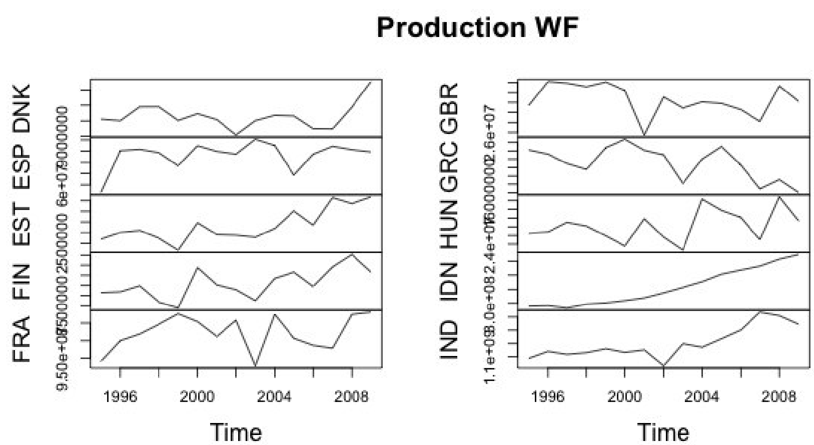
Appendix: a Graphical Illustration of Production and Consumption Water Footprint Paths

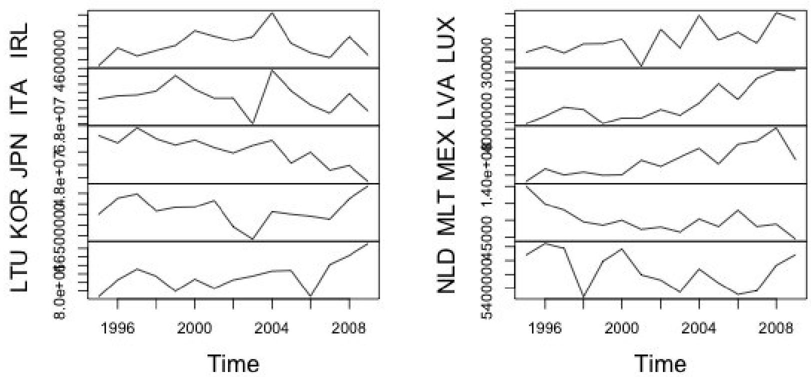
The WIOD database considers all 27 countries in the European Union, 17 other countries and one remaining "Rest of the World" aggregate region. In the following, we show stacked graphs (with five countries in each figure) of production and consumption time paths for water footprints in all individual countries.

Acronyms are as follows: AUS=Australia, AUT=Austria, BEL=Belgium, BGR=Bulgaria, BRA=Brazil, CAN=Canada, CHN=China, CYP=Cyprus, CZE=Czech Rep., DEU=Germany, DNK=Denmark, ESP=Spain, EST=Estonia, FIN=Finland, FRA=France, GBR=Great Britain, GRC=Greece, HUN=Hungary, IDN=Indonesia, IND=India, IRL=Ireland, ITA=Italy, JPN=Japan, KOR=Korea, LTU=Lithuania, LUX=Luxembourg, LVA=Latvia, MEX=Mexico, MLT=Malta, NLD=Netherlands, POL=Poland, PRT=Portugal, ROU=Romania, RUS=Russia, SVK=Slovakia, SVN=Slovenia, SWE=Sweden, TUR=Turkey, TWN=Taiwan, USA=United States.

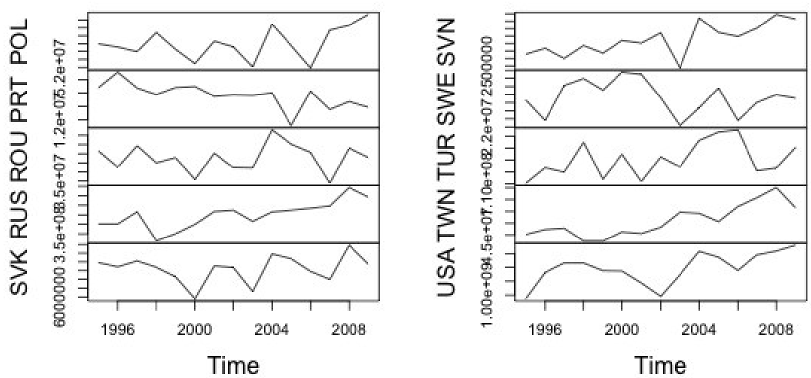




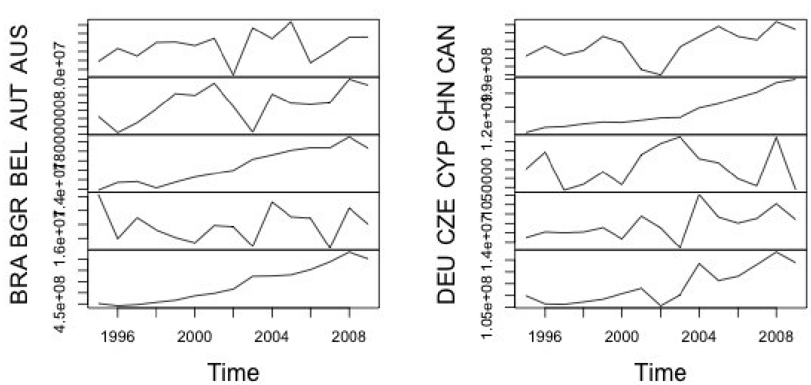
Production WF

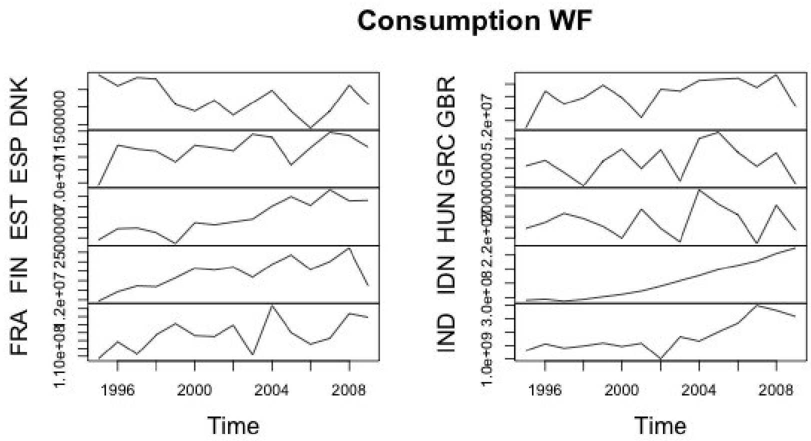


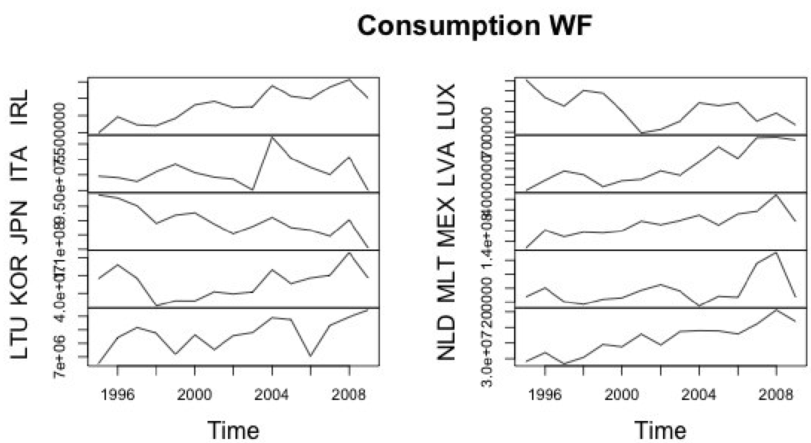
Production WF

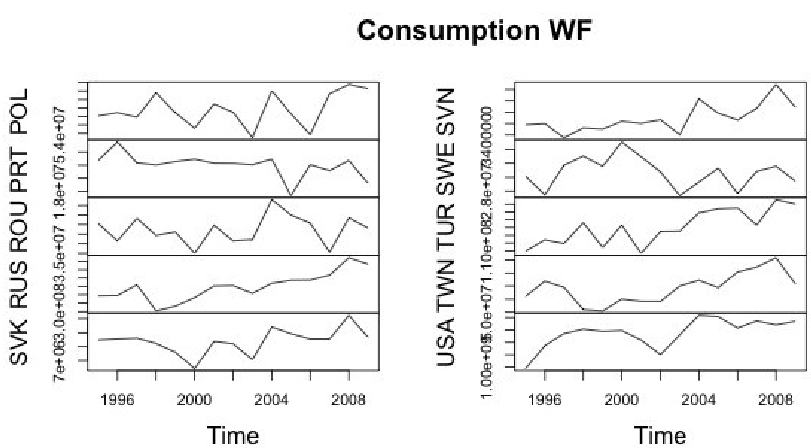


Consumption WF




Consumption WF
FRA FIN EST ESP DNK
IND IDN HUN GRC GBR
1996
2000
2004
2008
Time


Consumption WF
LTU KOR JPN ITA IRL
NLD MLT MEX LVA LUX
1996
2000
2004
2008
Time


Consumption WF
SVK RUS ROU PRT POL
USA TWN TUR SWE SVN
1996
2000
2004
2008
Time